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(71)(72) Applicant and Inventor: POLLASKY, Anthony [US/US]; 9920 N. 190th Street, Forest Lake, MN 55025 (US).

(74) Agent: TRUESDALE, Carole; Truesdale Law Office, 641 Nightingale Boulevard, Stillwater, MN 55082-5215 (US).

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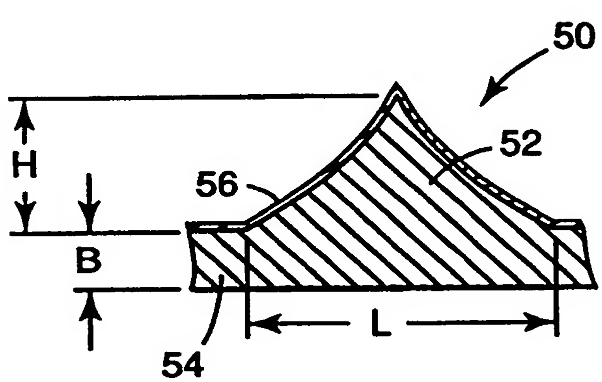

(57) Abstract

The present invention provides an abrasive material (50) comprising a base surface having a plurality of pyramidal shapes protruding therefrom the base surface and the protrusions (52) being formed of the same material, each protrusion (52) having a substantially triangular, square, or polygonal base and triangular sides which meet at an apex which substantially forms a point. The protrusions (52) provide intermixed cutting and planning edges in a pattern such that the material (50) is capable of abrading independent of direction of use. A coating (56) is applied to improve abrasive performance and reduce surface porosity. A method of forming the abrasive material (50) is also provided.

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ABRASIVE MATERIAL AND METHOD OF FORMING SAME

FIELD OF THE INVENTION

The present invention relates to an abrasive material produced by an etching process and suitable for sanding or smoothing a variety of surfaces and to a method of forming the abrasive material.

BACKGROUND OF THE INVENTION

Various abrading surfaces have been suggested over the years. Such surfaces include those wherein abrasive particles such as garnet, aluminum oxide, silicon carbide, grit of zirconia and alpha aluminum oxide monohydrate, single crystals of diamond or cubic boron nitride are adhered to a substrate. Also known are abrasive surfaces which are scored to provide grooves or punched to provide holes or openings with projections or burs surrounding the holes. Where grooves have been formed in metal sheets such as steel sheets, coating the surface or the cutting edge formed by the groove are also known. Metal abrasive sheets are known which are prepared by forming a cured polyvinylchloride negative master using a sheet of sandpaper and, then, electroplating the master to form the sheet.

Etching processes using a suitable resist to form a desired pattern in a metal substrate are also known. In one such technique, a resist pattern is applied to a thin flat steel plate in a predetermined pattern such as equal sized spots which can be round, elongate or polygonal. The plate is etched which an etchant such as an aqueous solution of ferric chloride to remove the desired amount of metal and form the pattern elements. It is reported that through variations of spraying mode, composition and temperature of the etching solution, the angle between the side of the protruding cutting elements and the original plate surface, as will as how far under the edge of the protecting pattern elements the etching will reach. One

improvement suggested is to provide parallel ridges on the etched side of the plate in the form of rhombic quadrangles either tangentially or helically to prevent the plate from curling.

Another improvement suggested is a resist pattern which is reported to give an even intermixing of fast working sharp points with smooth planing edges. The cutting teeth are formed in the shape of triangles or squares which come out of the etch process still sharp and usable due to the resist pattern which accentuates the corner points and eliminates under cutting of the upper surfaces of the cutting teeth. Each tooth bears an upper flat surface and is amenable to hardening by heat treating without excessive brittleness due to the tooth configuration. The upper flat surface of each tooth is reported to be typically about 3 mils with the width of the base and the height of the tooth being about twice that of the upper flat surface.

A process for producing cutting dies, particularly for use such as, for example, cutting adhesive tape to form labels, has been disclosed wherein multiple etching steps are used. A resist corresponding to the contour of a label to be propertied is formed on a steel plate and a first etching step is carried out, thereby forming a convex portion of a prescribed height. A second etching step is carried out whereby the resist extending from both sides of the top off the convex portion is removed and the steel plate is subjected to further etching. This second etching step may be carried out multiple times. The resist remaining on the top of the convex portion is then removed.

SUMMARY OF THE INVENTION

The present invention, in one aspect, provides an abrasive material comprising a base surface having a plurality of pyramidal shapes protruding therefrom the base surface and the protrusions being formed of the same material, each protrusion having a substantially triangular, square, or polygonal base and triangular sides which meet at an apex which substantially forms a point, the protrusions providing intermixing cutting and planing edges in a pattern such that the material is capable of abrading independent of direction of use and a coating

applied to the base surface and protrusions to improve abrasive performance and reduce surface porosity.

The coating applied to the base surface and protrusions to improve abrasive performance and reduce surface porosity can vary widely. Typical coatings include nickel or chrome plating or a diamond coating or plating in combination with diamond dust or boron nitride. The surface of the protrusions can optionally be heat treated to improve hardness as is well known to those skilled in the art.

Preferably, the triangular sides of the pyramidal protrusions have an inward arctuate slope. Such a slope provides greater longevity of the abarsive material due to lack of loading of material being abraded. The present invention provides rapid material removal from a workpiece, yet leaves a smooth surface on workpiece. The abrasive material of the invention can be provided with protrusions on both surfaces of the base material to prevent curling when the material is thin.

The present invention, in a further aspect, provides a method of forming an abrasive material comprising the steps of:

(a) providing a base material;

(b) applying to at least one surface of the base material a photoresist coating;

(c) placing over the photoresist a mask having a randomly directional triangular, square or polygonal pattern thereon;

(d) applying an etchant suitable for etching the base material for a time sufficient to provide a plurality of pyramidal protrusions on the base surface each protrusion having a substantially triangular, square or polygonal base and triangular sides which meet at an apex which substantially forms a point;

(e) removing the mask and the unexposed photoresist from at least the etched surface;

(f) applying a coating to the surface to reduce surface porosity and improve abrasion performance.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1a, 1b, and 1c are perspective views of pyramidal protrusions useful in the invention.

FIG. 2 is a perspective view of a preferred pyramidal protrusion of the invention having inward arctuate triangular sides.

FIG. 3 is a top view showing a suitable pattern of pyramidal protrusions for use in the abrasive material of the present invention.

FIG. 4a is a top view of a photoresist pattern suitable for use in producing an abrasive material of the invention.

FIG. 4b is a top view of an enlarged portion of the photoresist pattern shown in FIG. 4a.

FIG. 5 is side view of a pyramidal protrusion useful in the invention having a hard coating thereon.

FIG. 6 is a fragmented cross-section of an abrasive material of the present invention having pyramidal protrusions on each surface thereof.

DETAILED DESCRIPTION OF THE INVENTION

The abrasive material of the invention can be formed from any material susceptible to etching including, for example, stainless steel, carbon steel, aluminum alloys, iron-nickel-chrome alloys, and titanium; boron-filled elastomers, silica composites, fluorocarbon materials, graphite alloys, plastics, and the like. The thickness of the material is not particularly limited, but after etching should be suitably flexible where it will be used over a roller or suitably stiff when used as a flat abrasive. Of course, stiffness can be provided, if necessary, by attachment to a stiff substrate such as, for example, a metal plate or synthetic resin plate having suitable stiffness.

With respect to the drawings, like references number will be used with reference to like parts. FIGS. 1a, 1b, and 1c depict various possible embodiments

of the pyramidal protrusions of the abrading material of the invention with the bases of the pyramidal protrusions being triangular, square and pentagonal, respectively. Of course, other polygonal shapes can be used. In FIG. 1a, protrusion 10a is shown having triangular base 12a, triangular side 14a, and apex 16a. In FIG. 1b, protrusion 10b is shown having square base 12b, triangular side 14b and apex 16 b. In FIG. 1c, protrusion 10c is shown having polygonal base 12c, triangular side 14c and apex 16c.

The apex of each protrusion need not form a true point as shown in the FIGS., although this is the preferred configuration. The apexes of the protrusions may be slightly rounded or flat. However, this portion of the apexes should preferably be no greater in width than 20 percent of edges L, more preferably no more than 10 percent of edges L, edges L being shown in FIG. 5.

The depth of the inward arctuate slope on the triangular sides of the pyramidal protrusions which are found in the preferred embodiments of the invention can be from very slight, e.g., 1μm, to as great as about 175 μm. Such arctuate slopes can readily be seen in FIGS. 2 and 3 wherein protrusion 20 has arctuate sloped surfaces 22. The greater the size of the protrusions, the deeper the inward arctuate slope can be formed.

Preferably, the height H of the pyramidal protrusions from the etched surface can be in the range of about 25 μm to 1.5 mm, with higher pyramidal protrusions for normal coarse abrading, i.e., from about 125 μm to 375 μm, and lower pyramidal protrusions for finer abrading, i.e., from about 75 μm to 125 μm. The length of the edges L of the base is dependent on the height of the protrusions. Preferably, the ratio of the height of the protrusions from the etched surface to the length of the edge of the base is in the range of about 1:1 to 1:5, more preferably about 1:2 to 1:4, most preferably about 1:3. The thickness of the remaining base material B can vary widely and is not critical, with thinner base materials being used for more flexible abrasive materials and thicker base materials being used for stiffer abrasive materials as is well known to those skilled in the art. Such dimensions are indicated in the enlarged view of a portion of a hard coated abrasive material, seen in cross-section in FIG. 5.

The spacing S of the pyramidal protrusions can also vary widely, from about 0.75 mm to 30 mm apart, as measured from center to center of the circular pattern, with greater spacing for coarse abrading, i.e., 2 to 10 mm or more apart and less spacing for finer abrading, i.e., from about 0.75 to 1.5 mm apart. A resist pattern suitable for a medium abrasive grit is shown in FIG. 4a. An enlarged portion of the resist pattern is shown in FIG. 4b to demonstrate the detail of the pattern.

The fineness or coarseness of the abrasive material can also be adjusted by maintaining the height of the protrusions and the length of the base of the protrusions and adjusting the size of the resist pattern. Greater spacing between the protrusions provides coarser abrading material, while lesser spacing between the protrusions provides finer abrading material.

It is important that the pyramidal protrusions be oriented such that the cutting edges of the individual protrusions are oriented in different directions to provide the capability of abrading independent of direction of use. The pyramidal protrusions can be randomly oriented in various directions such as by designing the etching mask through the use of a computer-based random generator or an etching mask can be patterned which ensures random orientation as is well known to those skilled in the art. An example of a randomly oriented pattern is shown in FIGS. 4a and 4b. In FIG. 4a, a portion of mask pattern 40a is shown with spacing S. In FIG. 4b, an enlarged portion of a preferred mask pattern is shown in greater detail with cured resist portion 42 providing the desired protrusions after etching.

As previously described, a coating such as nickel or chrome plating; a diamond coating; or nickel or chrome plating in combination with diamond dust or Teflon®, tungsten, carbide or boron nitride particles can be applied to the surface of the abrasive material such as is shown in FIG. 5, wherein a portion of abrasive material 59 has protrusion 52, remaining base material 54, and coating 56.

The etching process can be carried out using well-known resist and etching materials. The resist can be applied using, for example, hot roll lamination, screen printing, gravure printing, dip coating and the like. For example, when the substrate is stainless steel, carbon steel, or the like, suitable etchants include ferric chloride, hydrochloric acid, nitric acid or mixtures thereof; for aluminum or aluminum alloys,

suitable etchants include sodium hydroxide; for titanium, suitable etchants include hydrofluoric acid; and plastics are generally etchable using various acids. The degree of etching can be adjusted by altering the concentration and temperature of the etchant solution and the method of application as is known to those skilled in the art. For example, when the base material, or substrate, is stainless steel, an aqueous ferric chloride solution of about 42° to 50° Baume can be used, the lower the Baume of the solution, generally the more arctuate the slope of the sides of the protrusions.

After etching, the resist can be removed by techniques well known to those skilled in the art. Alternatively, the resist can be retained on the surfaces of the sheet material, particularly on the non-abrasive side of the material when only one side is masked and pattern etched, which aids in prevention of curling. A suitable method of preventing curling involves etching both surfaces of the base material as shown in FIG. 6, wherein abrasive material 60 has protrusions 62 on each surface 61, 63 extending from the remaining base material 64.

Objects and advantages of this invention are further illustrated by the following examples, but the particular materials and amounts thereof recited in these examples, as well as other conditions and details, should not be construed to unduly limit this invention. All parts and percentages are by weight unless otherwise indicated.

EXAMPLES

Example 1

A stainless steel sheet about 250 μm thick was rinsed with dilute nitric acid and rinsed with water to remove any oils present on the surface. A photoresist, AX15 available from Morton Co., was coated on the surface to produce a dried coating about 39 μm thick. A mask having a pattern similar to that of FIG. 4a, but transparent in the areas shown as being dark, was placed over the photoresist. This composite was exposed to ultraviolet light to effect cure of the photoresist. The mask was removed and the unexposed photoresist was removed by rinsing with Developer KB1A, available from Morton Co., leaving a mask pattern similar to that of FIG. 4a. An aqueous ferric chloride solution about 42° Baume was applied to

the surface by spraying for about 11 minutes at about 50°C to effect etching of the exposed steel surface. The etched sheet was rinsed with water to suspend etching.

The pyramidal protrusions had a triangular base, each edge of which was about 400 µm. The height of the protrusions was about 150 µm with inward arctuate faces with maximum indentations of about 25 µm. The resulting sheet had only a slight tendency to curl due to the resist being allowed to remain on the non-etched surface. When restrained in a flat position, the resulting sheet performed excellently in a manner similar to 180 grit sandpaper, but without loading problems typical with sandpaper.

A portion of the sheet was plated with chrome to achieve a chrome thickness of about 5 µm. This product exhibited excellent abrasive performance with little loading and good longevity.

Example 2

An abrasive stainless steel sheet was prepared as in Example 1, except both surfaces of the stainless steel sheet were treated to provide pyramidal protrusions therein. Abrasive performance was found to be excellent and the sheet exhibited no curling.

Various modifications and alterations of this invention will become apparent to those skilled in the art without departing from the scope and spirit of this invention, and it should be understood that this invention is not to be unduly limited to the illustrative embodiments set forth herein.

What is claimed is:

1. An abrasive material comprising a base surface having a plurality of pyramidal shapes protruding therefrom the base surface and the protrusions being formed of the same material, each protrusion having a substantially triangular, square, or polygonal base and triangular sides which meet at an apex which substantially forms a point, said protrusions providing intermixed cutting and planing edges in a pattern such that said material is capable of abrading independent of direction of use and a coating applied to the base surface and protrusions to improve abrasive performance and reduce surface porosity.

2. The abrasive material of claim 1 wherein said protrusions have a height of about 25 μm to 1.5 μm.

3. The abrasive material of claim 1 wherein said protrusions have a height of about 125 μm to 375 μm.

4. The abrasive material of claim 1 wherein said protrusions have a height of about 75 μm to 175 μm.

5. The abrasive material of claim 1 wherein the ratio of the height of said protrusions from the etched surface to the length of the base of the protrusions is about 1:1 to 1:5.

6. The abrasive material of claim 1 wherein the ratio of the height of said protrusions from the etched surface to the length of the base of the protrusions is about 1:2 to 1.4.

7. The abrasive material of claim 1 wherein the ratio of the height of said protrusions from the etched surface to the length of the base of the protrusions is about 1:3.

8. The abrasive material of claim 1 wherein said triangular sides of said pyramidal protrusions have an inward arctuate slope.

9. The abrasive material of claim 8 wherein the depth of said inward arctuate slope is about 1 μm to 175 μm.

10. The abrasive material of claim 1 wherein said material is provided with protrusions on both surfaces of said base material.

11. The abrasive material of claim 1 wherein said material has protrusions on one surface thereof and photoresist on the other surface thereof.

12. The abrasive material of claim 1 wherein said base material is stainless steel, carbon steel, aluminum alloy, iron-nickel-chrome alloy, titanium, boron filled elastomer, silica composite, fluorocarbon materials, graphite alloys, or plastic.

13. The abrasive material of claim 1 further comprising a surface coating.

14. The abrasive article of claim 13 wherein said surface coating is plated chrome or nickel.

15. The abrasive material of claim 13 wherein said surface coating is diamond.

16. The abrasive material of claim 13 wherein said surface coating is plated chrome or nickel containing diamond dust or Teflon®, tungsten, carbide or boron nitride particles.

17. A method of forming an abrasive material comprising the steps of:

(a) providing a base material;

(b) applying to at least one surface of the base material a photoresist coating;

(c) placing over the photoresist a mask having a randomly directional triangular, square or polygonal pattern thereon;

(d) applying an etchant suitable for etching the base material for a time sufficient to provide a plurality of pyramidal protrusions on the base surface each protrusion having a substantially triangular, square or polygonal base and triangular sides which meet at an apex which substantially forms a point;

(e) removing the mask and the unexposed photoresist from at least the etched surface;

(f) applying a coating to the surface to reduce surface porosity and improve abrasion performance.

18. The method of claim 17 wherein said base material is stainless steel, carbon steel, aluminum alloy, titanium, boron-filled elastomer, silica composite, fluorocarbon material, graphite alloy or plastic.

19. The method of claim 17 wherein said resist is applied using hot roll lamination, screen printing, gravure printing or dip coating.

20. The method of claim 17 wherein said etchant is ferric chloride, hydrochloric acid, nitric acid, sodium hydroxide or hydrofluoric acid.

21. The method of claim 17 wherein said base material is stainless steel and said etchant is aqueous ferric chloride of 42° to 50° Baume.

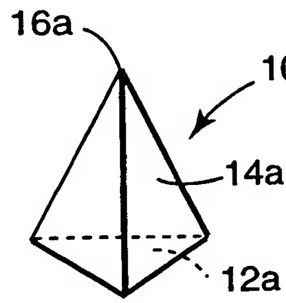

Fig. 1a

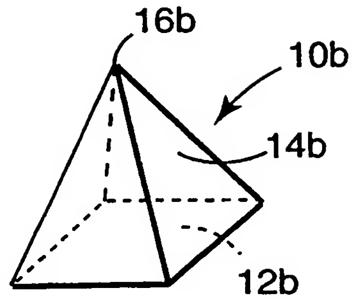

Fig. 1b

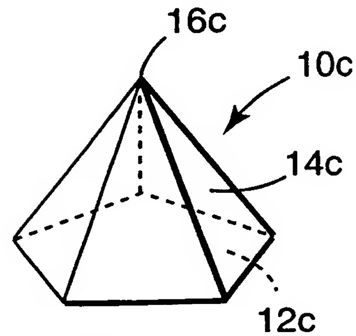

Fig. 1c

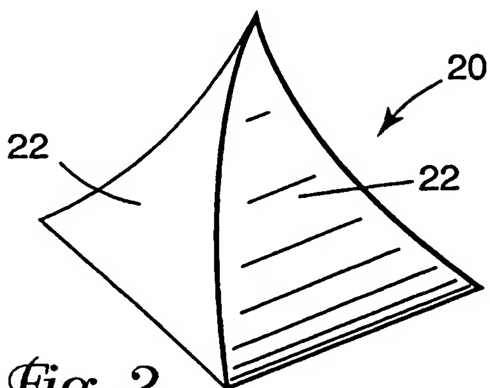

Fig. 2

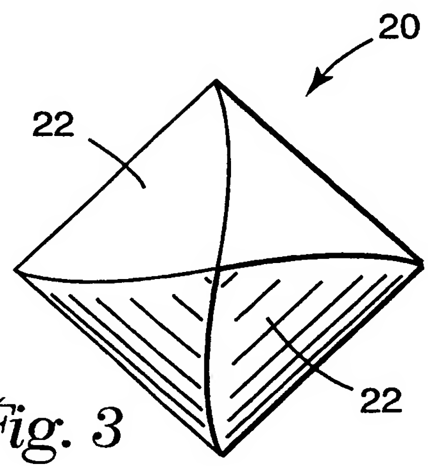

Fig. 3

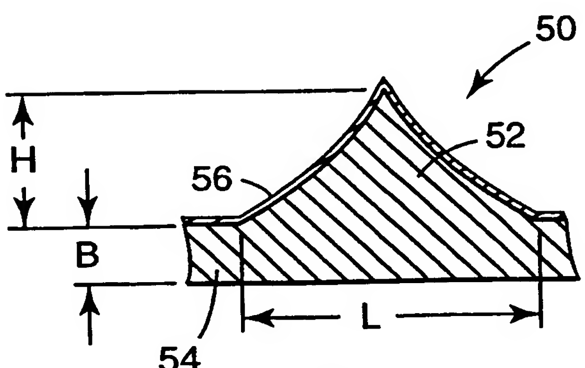

Fig. 5

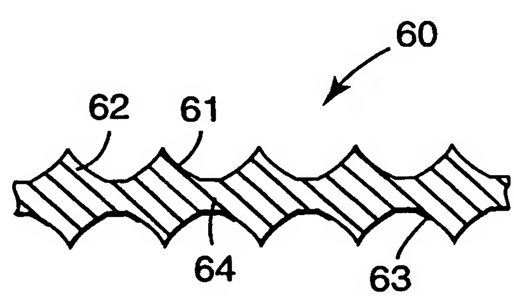

Fig. 6

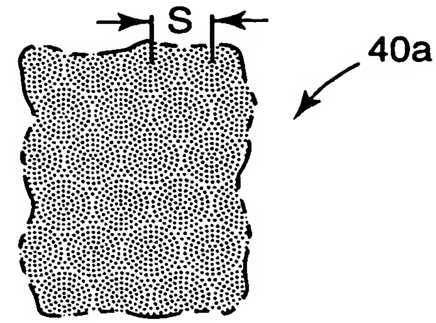

Fig. 4a

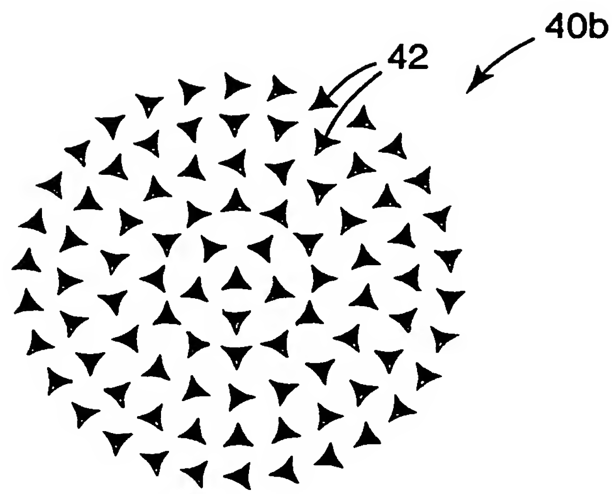

Fig. 4b

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/04102

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :B32B 3/00; B24B 1/00; B24D 11/00
US CL :Please See Extra Sheet.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 51/295,297; 428/143,144,148,161,164,172,687,698,908.8; 451/527,528

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US 5,500,273 A (HOLMES et al) 19 MARCH 1996, see Fig. Nos. 4,7 and column 15, lines 20-57.	1-16 ------ 17-21
X -- Y	US 5,551,959 A (MARTIN et al) 03 SEPTEMBER 1996, see Fig. Nos. 4 and corresponding text. —	1-16 ------ 17-21
Y -- A	US 5,580,647 A (LARSON et al) 03 DECEMBER 1996, see Fig.No. 2 and the entire Specification.	17-21 -------- 1-16

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
12 MAY 1999	28 MAY 1999

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A. CLASSIFICATION OF SUBJECT MATTER:
US CL :

51/295,297; 428/143,144,148,161,164,172,687,698,908.8; 451/527,528